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ACCP COMMENTARY

Impact of artificial intelligence on future clinical pharmacy research and scholarship

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Abstract

Almost every facet of modern biomedical research involves artificial intelligence (AI). This ACCP commentary forecasts the role of AI in clinical pharmacy research and scholarship. The potential benefits/opportunities together with the limitations/challenges of AI are reviewed for stages of the scientific method including (1) developing the research question(s), study design, and execution; (2) data analysis; and (3) reporting and dissemination of clinical pharmacy research. Benefits and opportunities of AI in clinical pharmacy research include streamlining hypothesis generation and facilitating study design, overcoming limitations of traditional statistical analysis techniques, facilitating manuscript development and dissemination, and expediting peer review. Limitations and challenges of AI include the introduction of biases in subject recruitment; generation of false information, also known as "AI hallucinations"; concern of "black box" analyses that are difficult to validate; potential legal liabilities; lack of accountability; and the need for investigators to ensure the accuracy and integrity of AI-generated content. In summary, rapid progress of AI capabilities has great potential to revolutionize and accelerate clinical pharmacy research and scholarship; however, it is also imperative to recognize and mitigate the challenges and limitations introduced by AI.

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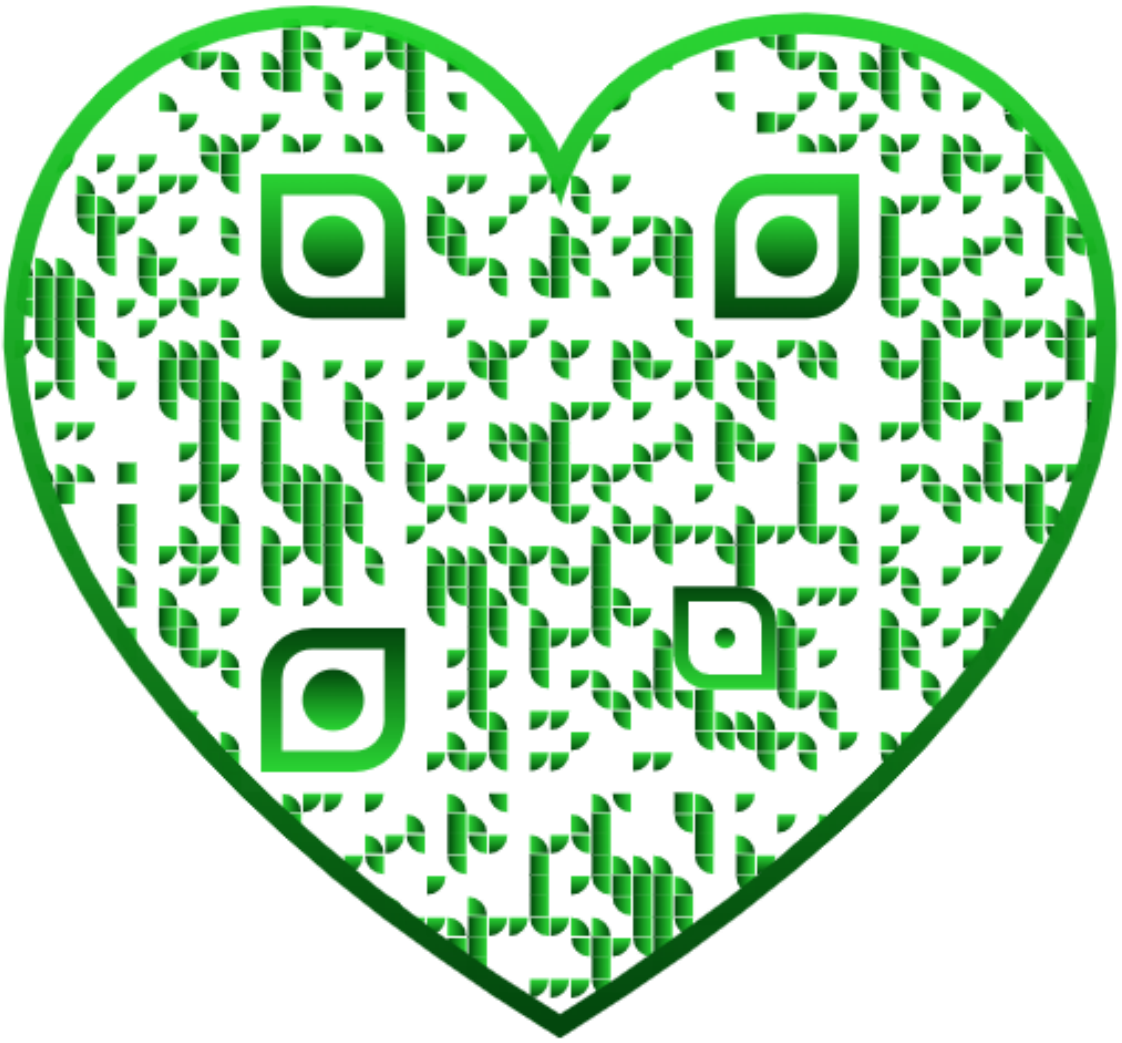

KEYWORDS
artificial intelligence, clinical pharmacy research, clinical pharmacy scholarship, machine learning

1 | INTRODUCTION

Artificial intelligence (AI) is defined as "a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments."[1] Often, terms like *machine learning* (*ML*), *natural language processing*, *large language model*, and *deep learning* are used interchangeably with AI; however, these techniques are different subcategories of AI that use algorithms or neural networks to recognize data patterns and features to make predictions and decisions. Generative AI is a subset of deep learning that is capable of producing high-quality text, images, and other content.[2]

Existence of AI dates back to the 1950s.[3] Although AI did not evolve continuously, various forms of reactive (i.e., streaming media recommendations/algorithms) and limited memory (ie, chatbots/virtual assistants) AI have become part of everyday life. We now live in the age of "big data," requiring computer assistance to process vast amounts of information. The ability of AI to continuously learn and improve, especially with the availability of ChatGPT (generative pre-trained transformer) by OpenAI in 2022, has significantly increased interest in and use of generative AI.[4]

This increased accessibility to AI affords clinical pharmacy investigators additional tools to research unanswered questions and generate hypotheses. However, although AI-driven clinical pharmacy research may offer significant benefits,[5] there are also numerous challenges and ethical considerations of which investigators need to be aware. The 2024 ACCP Research Affairs Committee was charged with forecasting the role of AI in clinical pharmacy research and scholarship. The committee considered various types of AI and the multifaceted nature of clinical pharmacy research. This commentary describes how generative AI may be used in the various stages of the scientific method including (1) developing the research question, study design, and study execution; (2) performing data analysis; and (3) reporting and disseminating clinical pharmacy research. Definitions for AI-related technical jargon used in this commentary can be found in the commentary titled "Forecasting the Impact of Artificial Intelligence on Clinical Pharmacy Practice."[6] Figure 1 summarizes the opportunities, limitations, and potential solutions.

2 | AI IN DEVELOPING THE RESEARCH QUESTION(S), STUDY DESIGN, AND STUDY EXECUTION

Generative AI has the potential to assist investigators in developing ideas and creating hypotheses by recognizing patterns and structures from existing data.[7] These models rely on deep learning techniques and neural networks to analyze, understand, and generate content

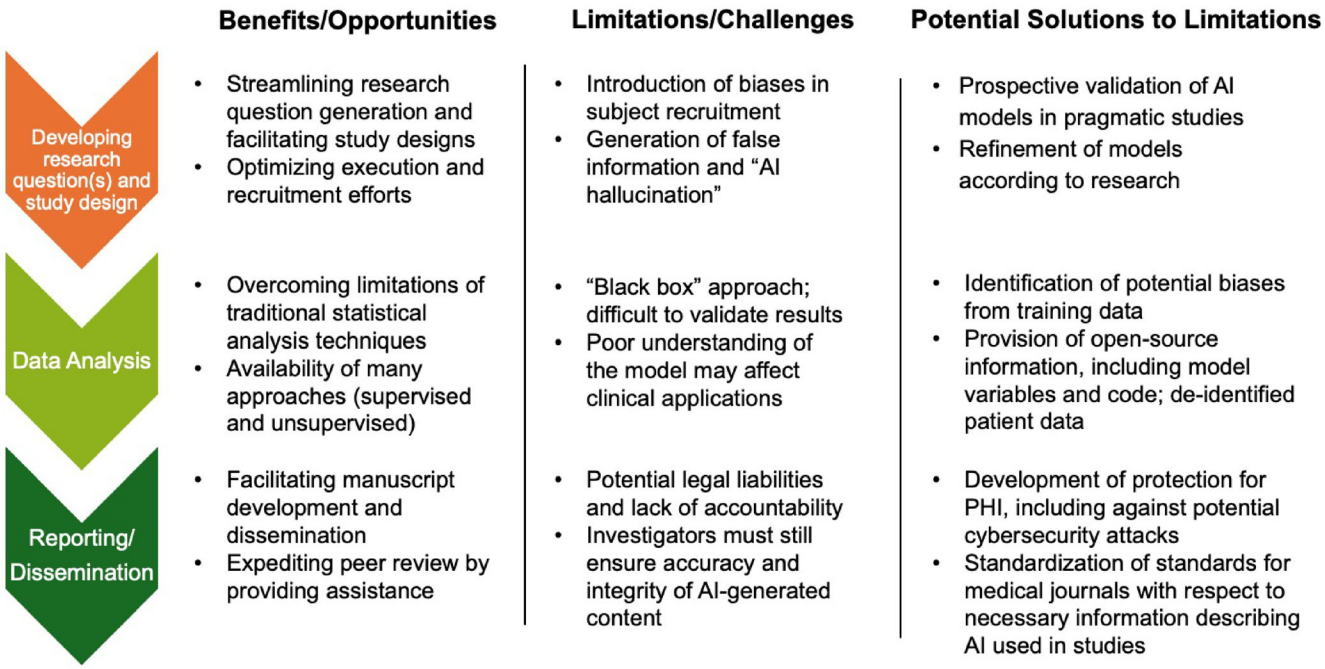
Benefits/Opportunities
Limitations/Challenges
Potential Solutions to Limitations
Developing research question(s) and study design
Streamlining research question generation and facilitating study designs
Optimizing execution and recruitment efforts
Introduction of biases in subject recruitment
Generation of false information and "AI hallucination"
Prospective validation of AI models in pragmatic studies
Refinement of models according to research
Data Analysis
Overcoming limitations of traditional statistical analysis techniques
Availability of many approaches (supervised and unsupervised)
"Black box" approach; difficult to validate results
Poor understanding of the model may affect clinical applications
Identification of potential biases from training data
Provision of open-source information, including model variables and code; de-identified patient data
Reporting/ Dissemination
Facilitating manuscript development and dissemination
Expediting peer review by providing assistance
Potential legal liabilities and lack of accountability
Investigators must still ensure accuracy and integrity of AI-generated content
Development of protection for PHI, including against potential cybersecurity attacks
Standardization of standards for medical journals with respect to necessary information describing AI used in studies

FIGURE 1 Opportunities, limitations, and potential solutions to limitations of ai on the scientific process. AI, artificial intelligence; PHI, protected health information.

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that closely resembles human-generated outputs.[7] Its automated pattern recognition can accelerate the innovation process, saving investigators time by analyzing large data sets to uncover novel connections and identify gaps or inconsistencies in current knowledge.[7] Existing tools enable investigators to conduct literature reviews, such as Semantic Scholar,[8] Elicit.org,[9] and Consensus.app.[10] Websites such as these draw from the available primary literature to identify connections between studies, allowing investigators to advance projects more efficiently. Using these tools may streamline the hypothesis-generating process by providing data analysis support, offering additional perspectives customized by investigators' prompts, and inspiring outside-the-box thinking.[7]

Artificial intelligence can also assist with literature review to determine the optimal study design, sample size, and plan for primary and secondary end points.[11–13] Artificial intelligence tools can extract and summarize trends from past studies or data sets, aiding future study development by building on previously published work.[11,14] Artificial intelligence software can also aid in determining an ideal sample size and assist in the scheduling process for patient recruitment.[15]

Artificial intelligence can also be beneficial in trial execution. This may include facilitating documentation of informed consent, subject randomization, and planning future study visits by analyzing staffing and patient appointment schedules to ensure patients are matched with staff members familiar to them.[11,12,16] Effective scheduling for clinical trials can lead to improved show rates, thus increasing the chances of meeting the sample size requirements and improving the study outcomes.[11,12]

Despite some potential benefits in the design and execution of clinical research posed by the presence of AI, potential ethical issues also exist. Although AI has shown the ability to predict the subjects most likely to enroll and participate in clinical trials,[17] this may create selection bias within the study recruitment design. For example, patients possessing characteristics of dropping out (eg, patients likely to experience severe adverse events[18]) may be less likely to be selected for recruitment by AI.[19] In addition, if these AI algorithms are not trained with diverse demographic data, individuals from underrepresented racial or ethnic groups may be invited less often to participate in the trials, potentially contributing to health disparities.[20] Furthermore, if AI is used to inform study design and attrition rates, there may be potential for unknowingly altering inclusion and exclusion criteria, thereby affecting the generalizability of results.[12] In that case, AI-generated trial design can potentially lead to inequitable access to clinical trials. Clinical pharmacy investigators using AI to aid in their study design and execution should be cognizant of potential limitations and how these can affect study enrollment and eventual study results.

Generative AI is only as good as the data sets it learns from. Generation of false information, also known as "AI hallucinations," can identify patterns where no true patterns exist, leading to nonsensical or inaccurate outputs; this is a problem companies are said to be improving/resolving.[21,22] Using these tools requires human oversight to ensure the research questions generated are relevant and aligned with research objectives.[23] It would be a mistake to discount the value of human creativity and originality, education, training, and interpersonal interactions when conducting research. These remain essential for conducting relevant and innovative research.

3 | AI IN DATA ANALYSIS

Machine learning approaches have been used in a variety of studies that are commonly performed by pharmacy investigators.[24,25] Machine learning employs advanced algorithms and statistical techniques to analyze data and make predictions, branching into supervised, unsupervised, semi-supervised, and reinforcement learning.[26,27] Supervised learning uses training sets consisting of data already labeled for classification and prediction that allow for development of models that correctly predict the predetermined outcome. The supervised learning model can then be applied to new data sets for analysis. Unsupervised learning, however, does not use pre-labeled training sets. Instead, it infers similarities to cluster complex data and reduce data dimensions. Semi-supervised learning employs both labeled and unlabeled data, mirroring real-world scenarios. Reinforcement learning is similar to unsupervised learning in that no prelabeled training sets are used. However, reinforcement learning incorporates positive and negative feedback that mimics a trial-and-error approach to optimize behaviors and improve analytical performance.

Machine learning models are developed, in part, to analyze complex and large data sets that overcome the limitations of regression modeling. In medical research, regression models (eg, risk prediction models) have historically been used to predict how a dependent variable influences an outcome based on the assumption that linear correlations exist.[28] However, in medical research, there are not always linear correlations between variables and outcomes. Machine learning models may better account for nonlinear relationships, which may be of particular importance when analyzing large data sets such as those extracted from electronic health records.[29] Machine learning has the promise of driving advances in common research areas conducted by clinical pharmacy investigators such as predicting drug-related problems, optimizing pharmacotherapy, and advancing precision medicine.[30–32]

Nevertheless, challenges persist such as variability in research methods, data management issues, and the complexity of transforming raw clinical data into ML-compatible formats.[33,34] Because of the complexity of algorithms, ML analysis essentially functions in a "black box," making it difficult to validate results.[29] For example, AI can be used to create and analyze fake data sets with results that appear authentic.[21] Without fully understanding how the data set was generated or analyzed, it may be difficult to detect invalid results. Lack of understanding how ML models function may also lead to simplified insights that are not practically useful, especially in future clinical applications.

Clinical pharmacy investigators without in-depth training in ML will require collaboration with data scientists and/or statisticians who are able to provide ML modeling support. In addition, clinical pharmacy investigators will benefit from professional development

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focused on how ML functions, including limitations and ethical concerns, to allow for critical assessment of the appropriateness of data sets. Pursuing self-directed learning through online courses in these areas is advisable. Attending major professional conferences, such as those hosted by the American Medical Informatics Association, can provide valuable insights and networking opportunities. In addition, programming skills are essential for understanding and implementing ML and deep learning models. Investigators may consider enrolling in computer science and programming courses, especially those that provide instruction in Python, R, and structured query language. These foundational skills will enable investigators to effectively apply advanced computational techniques in their research.

4 | AI IN REPORTING AND DISSEMINATION

Artificial intelligence is a regulatory moving target with multiple potential legal liabilities. Such issues include algorithmic transparency, cybersecurity vulnerabilities, bias and discrimination, lack of contestability, legal personhood issues, intellectual property concerns, adverse effects on individuals, privacy and data protection concerns, liability for damages, and lack of accountability.[35] Transparency is crucial in employing AI within future clinical pharmacy research and scholarship given its rapid development and as-yet unknown functionalities.[36]

Of further significance to both investigators and journal editors is the potential role of AI in facilitating research dissemination and expediting the manuscript review process. Although virtually all journals require disclosure of AI use by investigators, the details of content and location may vary.[37] Use of AI-assisted language editing to improve manuscript readability is generally considered acceptable and may promote equity by reducing language barriers to publication.[38] However, existing tools still have notable limitations when used for this purpose.[39] Artificial intelligence technologies do not meet the criteria for authorship[40]; rather, investigators are responsible for ensuring the accuracy and integrity of all AI-generated content. Artificial intelligence algorithms may also assist authors in more accurately matching the content of their paper to related scientific journals.[41]

Investigators are encouraged to familiarize themselves with existing guidance documents for the use and reporting of AI in clinical research.[42–47] The Consolidated Standards of Reporting Trials (CONSORT) 2010 checklist was initially developed to improve the completeness of reporting in randomized controlled trials.[48] Recently, these criteria were updated to address needed guidance on reporting in studies that evaluate interventions on the basis of an AI component.[43] These newly developed CONSORT-AI criteria complement additional guidance documents on integrating AI into various areas of scientific inquiry and reporting. Recommendations are made for specific components to be included in each major section of a manuscript, facilitating the transparent reporting of AI intervention studies, allowing for critical evaluation of the evidence and methods.

Although no substitute for the subject matter expertise and reasoned evaluations of an article's novelty, significance, and rigor performed by human peer reviewers, AI tools may support initial quality control and streamline pre-review processes via scope verification, abstract/reviewer matching, methodological/statistical checks, and plagiarism detection.[49] Plagiarism detection may include early flagging of AI-generated articles, which often cannot be distinguished from human-written text during initial abstract review[50] but may contain significant factual inaccuracies.[51,52] Artificial intelligence tools may also allow journals to audit peer review decision outcomes by identifying manuscript features predictive of a recommendation for acceptance or rejection. In one AI model, readability and formatting often predicted the final recommendation.[53] Journal editors concerned that papers may be rejected on the basis of relatively superficial correctable features rather than their scientific merit may choose to incorporate detection of these predictors into the prescreening process and advise authors to revise flagged papers for clarity before peer review. Conversely, if deemed a good proxy indicator of overall quality, results of AI pre-scoring may assist editors in deciding which papers warrant further review versus desk rejection. These scores may be shared with peer reviewers as an early quality flag to assist in their decision-making. Although these AI tools may have the potential to expose and mitigate certain biases, journal editors must also be alert to the risk of perpetuating existing bias.

5 | CONCLUSION

Much of the rapid progress of AI capabilities has great potential to revolutionize and accelerate clinical pharmacy research and scholarship. The ethical, social, and political challenges AI introduces in medical research, including issues related to data management, health disparities, and human relationships, demand a careful approach. Evidence has suggested that employing both technical and nontechnical approaches—including ethical design, compliance with regulations, and stakeholder engagement—is needed to ensure AI development is consistent with modern societal demands.[54] Despite skepticism, the transformative power of AI is here to stay, and those using existing scientific research strategies must keep pace by harnessing its power. To ensure AI provides a transparent and data-driven approach to improving research efficiency and effectiveness, a balance must be struck to mitigate potential challenges and limitations, aiming to improve the quality and quantity of research output among clinical pharmacy investigators.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interests. Jerry Bauman is founding editor-in-chief of the Journal of the American College of Clinical Pharmacy. C. Lindsay DeVane is a non-voting member of the ACCP Foundation, Ltd. Board of Directors.

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REFERENCES

1. US Department of State. Artificial intelligence (AI). 2024 www.state.gov/artificial-intelligence
2. IBM. What is generative AI? 2024 https://research.ibm.com/blog/what-is-generative-AI
3. Harvard KC. Griffin Graduate School of Arts and Sciences. The history of artificial intelligence. 2019 https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/
4. Forbes. A short history of ChatGPT: how we got to where we are today. 2023 https://www.forbes.com/sites/bernardmarr/2023/05/19/a-short-history-of-chatgpt-how-we-got-to-where-we-are-today/?sh=5abebd09674f
5. Smoke S. Artificial intelligence in pharmacy: a guide for clinicians. *Am J Health-Syst Pharm*. 2024;81:641–646. https://doi.org/10.1093/ajhp/zxae051
6. Wong A, Flanagan T, Covington EW, Nguyen E, Linn D, Brummel G, et al. Forecasting the impact of artificial intelligence on clinical pharmacy practice. *J Am Coll Clin Pharm*. 2025;8(4):302–310. https://doi.org/10.1002/jac5.70004
7. Ray PP. ChatGPT: a comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope. *Internet Things Cyberphys Syst*. 2023;3:121–154. https://doi.org/10.1016/j.iotcps.2023.04.003
8. Allen Institute for AI. Semantic scholar. 2024 https://www.semanticscholar.org/
9. Elicit. 2024. https://elicit.com/
10. Consensus. Consensus: AI search engine for research. 2024 https://consensus.app/
11. Fogel DB. Factors associated with clinical trials that fail and opportunities for improving the likelihood of success: a review. *Contemp Clin Trials Commun*. 2018;11:156–164. https://doi.org/10.1016/j.conctc.2018.08.001
12. Lee CS, Lee AY. How artificial intelligence can transform randomized controlled trials. *Transl Vis Sci Technol*. 2020;9(2):9. https://doi.org/10.1167/tvst.9.2.9
13. Weissler EH, Naumann T, Andersson T, Ranganath R, Elemento O, Luo Y, et al. The role of machine learning in clinical research: transforming the future of evidence generation. *Trials*. 2021;22(1):537. https://doi.org/10.1186/s13063-021-05489-x
14. Hripcsak G, Austin JH, Alderson PO, Friedman C. Use of natural language processing to translate clinical information from a database of 889,921 chest radiographic reports. *Radiology*. 2002;224(1):157–163. https://doi.org/10.1148/radiol.2241011118
15. Ismail A, Al-Zoubi T, El Naqa I, Saeed H. The role of artificial intelligence in hastening time to recruitment in clinical trials. *BJR Open*. 2023;5(1):20220023. https://doi.org/10.1259/bjro.20220023
16. Branke J, Nguyen S, Pickardt CW, Zhang M. Automated design of production scheduling heuristics: a review. *Trans Evol Comp*. 2016;20(1):110–124. https://doi.org/10.1109/TEVC.2015.2429314
17. Vazquez J, Abdelrahman S, Byrne LM, Russell M, Harris P, Facelli JC. Using supervised machine learning classifiers to estimate likelihood of participating in clinical trials of a de-identified version of ResearchMatch. *J Clin Transl Sci*. 2020;5(1):e42. https://doi.org/10.5863/1551-6776-29.3.336
18. Zhang B, Zhang L, Chen Q, Jin Z, Liu S, Zhang S. Harnessing artificial intelligence to improve clinical trial design. *Commun Med Lond*. 2023;3(1):191. https://doi.org/10.1038/s43856-023-00425-3
19. Bennemann B, Schwartz B, Giesemann J, Lutz W. Predicting patients who will drop out of out-patient psychotherapy using machine learning algorithms. *Br J Psychiatry*. 2022;220(4):1–10. https://doi.org/10.1192/bjp.2022.17
20. US Department of Health and Human Services Office of Minority Health. Shedding light on healthcare algorithmic and artificial intelligence bias. 2024 https://minorityhealth.hhs.gov/news/shedding-light-healthcare-algorithmic-and-artificial-intelligence-bias
21. Taloni A, Scorcia V, Giannaccare G. Large language model advanced data analysis abuse to create a fake data set in medical research. *JAMA Ophthalmol*. 2023;141(12):1174–1175. https://doi.org/10.1001/jamaophthalmol.2023.5162
22. IBM. What are AI hallucinations? 2024 https://www.ibm.com/topics/ai-hallucinations
23. Van Dis EAM, Bollen J, Zuidema W, Van Rooij R, Bockting CL. ChatGPT: five priorities for research. *Nature*. 2023;614(7947):224–226. https://doi.org/10.1038/d41586-023-00288-7
24. Ranchon F, Chanoine S, Lambert-Lacroix S, Bosson JL, Moreau-Gaudry A, Bedouch P. Development of artificial intelligence powered apps and tools for clinical pharmacy services: a systematic review. *Int J Med Inform*. 2023;172:104983. https://doi.org/10.1016/j.ijmedinf.2022.104983
25. Chalasani SH, Syed J, Ramesh M, Patil V, Pramod Kumar TM. Artificial intelligence in the field of pharmacy practice: a literature review. *Explor Res Clin Soc Pharm*. 2023;12:100346. https://doi.org/10.1016/j.rcsop.2023.100346
26. Sarker IH. Machine learning: algorithms, real-world applications and research directions. *SN Comput Sci*. 2021;2(3):160. https://doi.org/10.1007/s42979-021-00592-x
27. Habehh H, Gohel S. Machine learning in healthcare. *Curr Genomics*. 2021;22(4):291–300. https://doi.org/10.2174/1389202922666210705124359
28. Bzovsky S, Phillips MR, Guymer RH, Wykoff CC, Thabane L, Bhandari M, et al. The clinician's guide to interpreting a regression analysis. *Eye (Lond)*. 2022;36(9):1715–1717. https://doi.org/10.1038/s41433-022-01949-z
29. Goldstein BA, Navar AM, Carter RE. Moving beyond regression techniques in cardiovascular risk prediction: applying machine learning to address analytic challenges. *Eur Heart J*. 2017;38(23):1805–1814. https://doi.org/10.1093/eurheartj/ehw302
30. Scheibner A, Betthauser KD, Bewley AF, Juang P, Lizza B, Micek S, et al. Machine learning to predict vasopressin responsiveness in patients with septic shock. *Pharmacotherapy*. 2022;42(6):460–471. https://doi.org/10.1002/phar.2683
31. Mo X, Chen X, Zeng H, Zheng W, Ieong C, Li H, et al. Tacrolimus in the treatment of childhood nephrotic syndrome: machine learning detects novel biomarkers and predicts efficacy. *Pharmacotherapy*. 2023;43(1):43–52. https://doi.org/10.1002/phar.2749

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32. Goyal J, Ng DQ, Zhang K, Chan A, Lee J, Zheng K, et al. Using machine learning to develop a clinical prediction model for SSRI-associated bleeding: a feasibility study. *BMC Med Inform Decis Mak*. 2023;23(1):105. https://doi.org/10.1186/s12911-023-02206-3
33. Andaur Navarro CL, Damen JAA, van Smeden M, Takada T, Nijman SWJ, Dhiman P, et al. Systematic review identifies the design and methodological conduct of studies on machine learning-based prediction models. *J Clin Epidemiol*. 2023;154:8–22. https://doi.org/10.1016/j.jclinepi.2022.11.015
34. Zhang A, Xing L, Zou J, Wu JC. Shifting machine learning for healthcare from development to deployment and from models to data. *Nat Biomed Eng*. 2022;6(12):1330–1345. https://doi.org/10.1038/s41551-022-00898-y
35. Rodrigues R. Legal and human rights issues of AI: gaps, challenges and vulnerabilities. *J Respons Technol*. 2020;4:100005. https://doi.org/10.1016/j.jrt.2020.100005
36. Flanagin A, Pirracchio R, Khera R, Berkwits M, Hswen Y, Bibbins-Domingo K. Reporting use of AI in research and scholarly publication-JAMA network guidance. *JAMA*. 2024;331(13):1096–1098. https://doi.org/10.1001/jama.2024.3471
37. Ganjavi C, Eppler MB, Pekcan A, Biedermann B, Abreu A, Collins GS, et al. Publishers' and journals' instructions to authors on use of generative artificial intelligence in academic and scientific publishing: bibliometric analysis. *BMJ*. 2024;384:e077192. https://doi.org/10.1136/bmj-2023-077192
38. Seghier ML. Using ChatGPT and other AI-assisted tools to improve manuscripts readability and language. *Int J Imaging Syst Technol*. 2023;33(3):773–775. https://doi.org/10.1002/ima.22902
39. Abuyaman O. Strengths and weaknesses of ChatGPT models for scientific writing about medical vitamin B_{12}: mixed methods study. *JMIR Form Res*. 2023;7:e49459. https://doi.org/10.2196/49459
40. International Committee of Medical Journal Editors. Defining the role of authors and contributors. 2024 https://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html
41. Feng X, Zhang H, Ren Y, Shang P, Zhu Y, Liang Y, et al. The deep learning-based recommender system "Pubmender" for choosing a biomedical publication venue: development and validation study. *J Med Internet Res*. 2019;21(5):e12957. https://doi.org/10.2196/12957
42. Collins GS, Dhiman P, Andaur Navarro CL, Ma J, Hooft L, Reitsma JB, et al. Protocol for development of a reporting guideline (TRIPOD-AI) and risk of bias tool (PROBAST-AI) for diagnostic and prognostic prediction model studies based on artificial intelligence. *BMJ Open*. 2021;11(7):e048008. https://doi.org/10.1136/bmjopen-2020-048008
43. Cruz Rivera S, Liu X, Chan AW, Denniston AK, Calvert MJ, SPIRIT-AI and CONSORT-AI Working Group. Guidelines for clinical trial protocols for interventions involving artificial intelligence: the SPIRIT-AI extension. *Lancet Digit Health*. 2020;2(10):e549–e560. https://doi.org/10.1016/S2589-7500(20)30219-3
44. Hernandez-Boussard T, Bozkurt S, Ioannidis JPA, Shah NH. MINIMAR (MINimum information for medical AI reporting): developing reporting standards for artificial intelligence in health care. *J Am Med Inform Assoc*. 2020;27(12):2011–2015. https://doi.org/10.1093/jamia/ocaa088
45. Norgeot B, Quer G, Beaulieu-Jones BK, Torkamani A, Dias R, Gianfrancesco M, et al. Minimum information about clinical artificial intelligence modeling: the MI-CLAIM checklist. *Nat Med*. 2020;26(9):1320–1324. https://doi.org/10.1038/s41591-020-1041-y
46. Sounderajah V, Ashrafian H, Golub RM, Shetty S, de Fauw J, Hooft L, et al. Developing a reporting guideline for artificial intelligence-centred diagnostic test accuracy studies: the STARD-AI protocol. *BMJ Open*. 2021;11(6):e047709. https://doi.org/10.1136/bmjopen-2020-047709
47. Vasey B, Nagendran M, Campbell B, Clifton DA, Collins GS, Denaxas S, et al. Reporting guideline for the early-stage clinical evaluation of decision support systems driven by artificial intelligence: DECIDE-AI. *Nat Med*. 2022;28(5):924–933. https://doi.org/10.1038/s41591-022-01772-9
48. Schulz KF, Altman DG, Moher D, CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. *Ann Intern Med*. 2010;152(11):726–732. https://doi.org/10.7326/0003-4819-152-11-201006010-00232
49. Kousha K, Thelwall M. Artificial intelligence to support publishing and peer review: a summary and review. *Learned Publ*. 2024;37(1):4–12. https://doi.org/10.1002/leap.1570
50. Abani S, Volk HA, de Decker S, Fenn J, Rusbridge C, Charalambous M, et al. ChatGPT and scientific papers in veterinary neurology; is the genie out of the bottle? *Front Vet Sci*. 2023;10:1272755. https://doi.org/10.3389/fvets.2023.1272755
51. Ariyaratne S, Iyengar KP, Nischal N, Chitti Babu N, Botchu R. A comparison of ChatGPT-generated articles with human-written articles. *Skeletal Radiol*. 2023;52(9):1755–1758. https://doi.org/10.1007/s00256-023-04340-5
52. HU H, Kaakour AH, Rachitskaya A, Srivastava S, Sharma S, Mammo DA. Evaluation and comparison of ophthalmic scientific abstracts and references by current artificial intelligence chatbots. *JAMA Ophthalmol*. 2023;141(9):819–824. https://doi.org/10.1001/jamaophthalmol.2023.3119
53. Checco A, Bracciale L, Loreti P, Pinfield S, Bianchi G. AI-assisted peer review. *Hum Soc Sci Commun*. 2021;8(1):25. https://doi.org/10.1057/s41599-020-00703-8
54. Wellnhofer E. Real-world and regulatory perspectives of artificial intelligence in cardiovascular imaging. *Front Cardiovasc Med*. 2022;9:890809. https://doi.org/10.3389/fcvm.2022.890809

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